Integrating Ocean Color Observations and Nowcast/Forecast of Bio-Optical Properties into the Naval Research Laboratory Coastal Ocean Model (NCOM)

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LONG-TERM GOALS

The long-term goal of this effort is to provide a framework for assimilating satellite ocean color observations into coupled bio-optical/hydrodynamic ocean models that may provide a forecast of the fully three-dimensional field properties that define the marine environment over a range of spatial/temporal scales and are of pertinent tactical interest to the U.S. Navy.

OBJECTIVES

The immediate scientific objectives of this long-term effort are to: (1) use satellite ocean color algorithms that quantify and partition near-surface inherent optical properties (IOP's) to establish a regional IOP climatology, with particular emphasis upon the partition of the multi-spectral absorption coefficient between colored dissolved organic matter (CDOM) and living phytoplankton biomass, (2) examine the relationship between IOP variance and three-dimensional thermal field variability as determined by existing data assimilative and interpolative systems (i.e., the Modular Ocean Data Assimilation System – MODAS), (3) use a combination of statistical inference and numerical modeling techniques to provide a three-dimensional optical property estimate (nowcast) that is informed by and integrated with systems that estimate the thermal and velocity fields, and (4) use results from and knowledge gained in objectives 1-3 to refine existing coupled real-time modeling efforts towards an efficient, accurate, and portable prognostic tool for the optical battle space environment.

APPROACH

The technical approach is to synthesize continuing efforts within the Naval Research Laboratory – Stennis Space Center (NRL-SSC) Ocean Sciences Branch with those occurring within the NRL-SSC Ocean Modeling and Prediction Branch to provide the project with the most advanced data products, techniques, and modeling efforts. Specifically, Zhongping Lee and Paul Martinolich are providing products from the ocean color "Quasi-Analytical Algorithms" (Lee et al., 2002) using Sea-viewing Wide-Field-of-view Sensor (SeaWiFS) and Moderate Resolution Imaging Spectroradiometer (MODIS) ocean color data. This includes estimates of the multi-spectral absorption coefficients for colored

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detritus (dissolved and particulate), phytoplankton pigments, as well as spectral backscattering. These data and products are then combined with dynamic MODAS estimates of the three-dimensional thermal and salinity fields (Fox et al., 2002). MODAS is under continuing development by Clark Rowley and Charlie Barron. These two data streams are to be merged into a single optical-thermal-hydrodynamic nowcast of the marine environment that may then initialize and/or adjust real-time coupled modeling efforts currently underway in John Kindle's Coupled Processes Group using the Navy Coastal Ocean Model (Kindle et al., 2005).

WORK COMPLETED

Work in the project was essentially completed in FY05, the results of which were presented at the AGU Fall meeting in San Francisco and the Ocean Sciences meeting in Honolulu Hawaii in February of 2006. A journal article based on the work was also submitted to The Journal of Geophysical Research.

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IMPACT/APPLICATIONS

The results suggest that a global, portable system that assimilates ocean color data into a fully-three dimensional nowcast of the temperature, salinity, and optical fields may be rapidly developed and transitioned to provide support for a wide range of Naval operations: anti-submarine warfare, mine detection, AUV operation, and detection of enemy incursion. Such a system would then also serve as initialization for coupled bio-optical/hydrodynamic model simulations that seek to provide a forecast of these fields.

RELATED PROJECTS

NRL, "Coupled Bio-Optical and Physical Processes (CoBiOPP)" (PI: J. Kindle)
I. Real-time bio-physical modeling of the West Coast Ecosystem using a biogeochemical model is currently underway at NRL-SSC. Results from this project will provide additional techniques to use ocean color data to initialize, correct, and validate coupled model simulations of the California current system.

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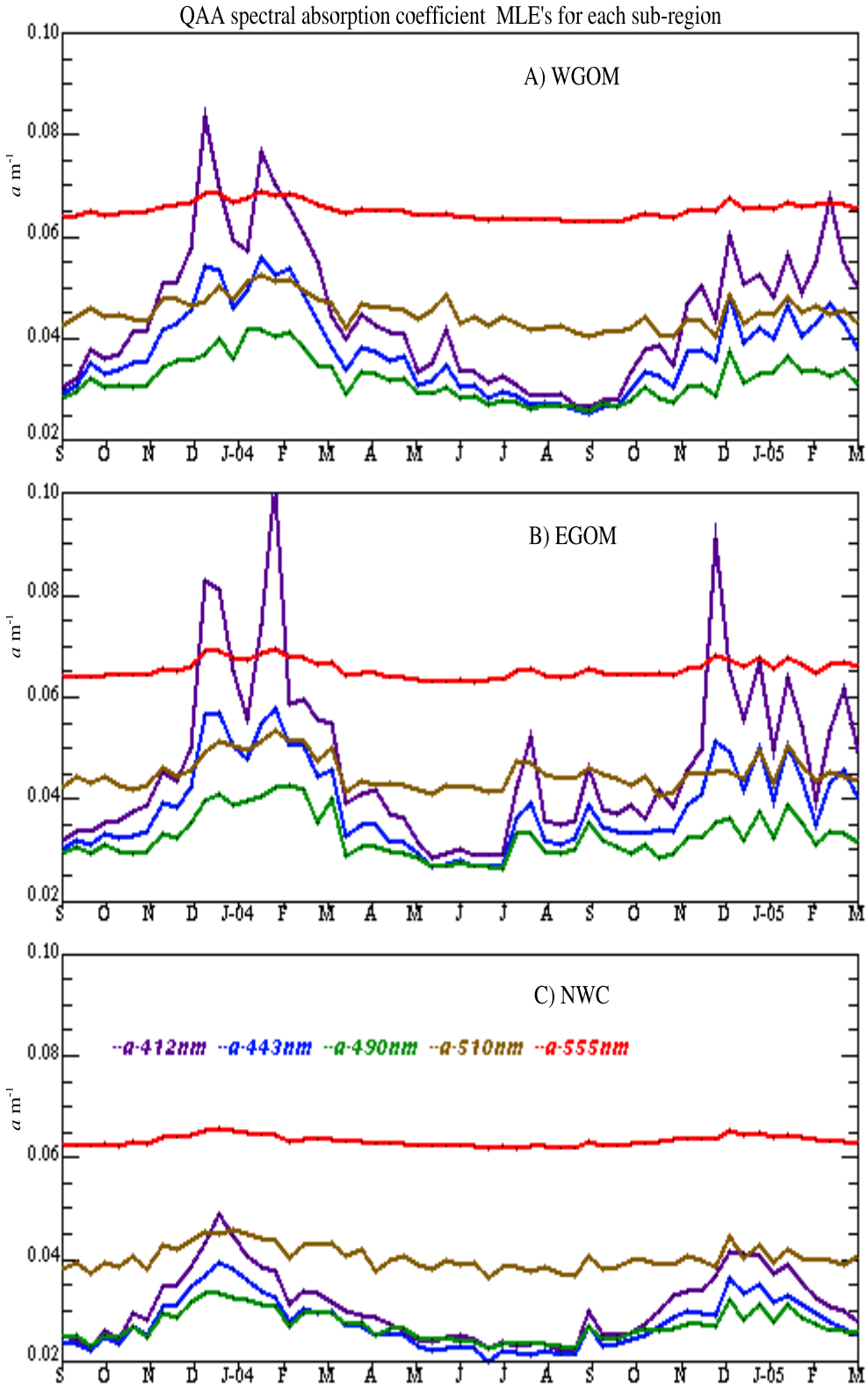

Figure 1. 10 day Maximum Likelihood Estimators (MLE's, approximately the geometric mean) of QAA total absorption coefficients for A) WGOM, B) EGOM, and C) NWC.

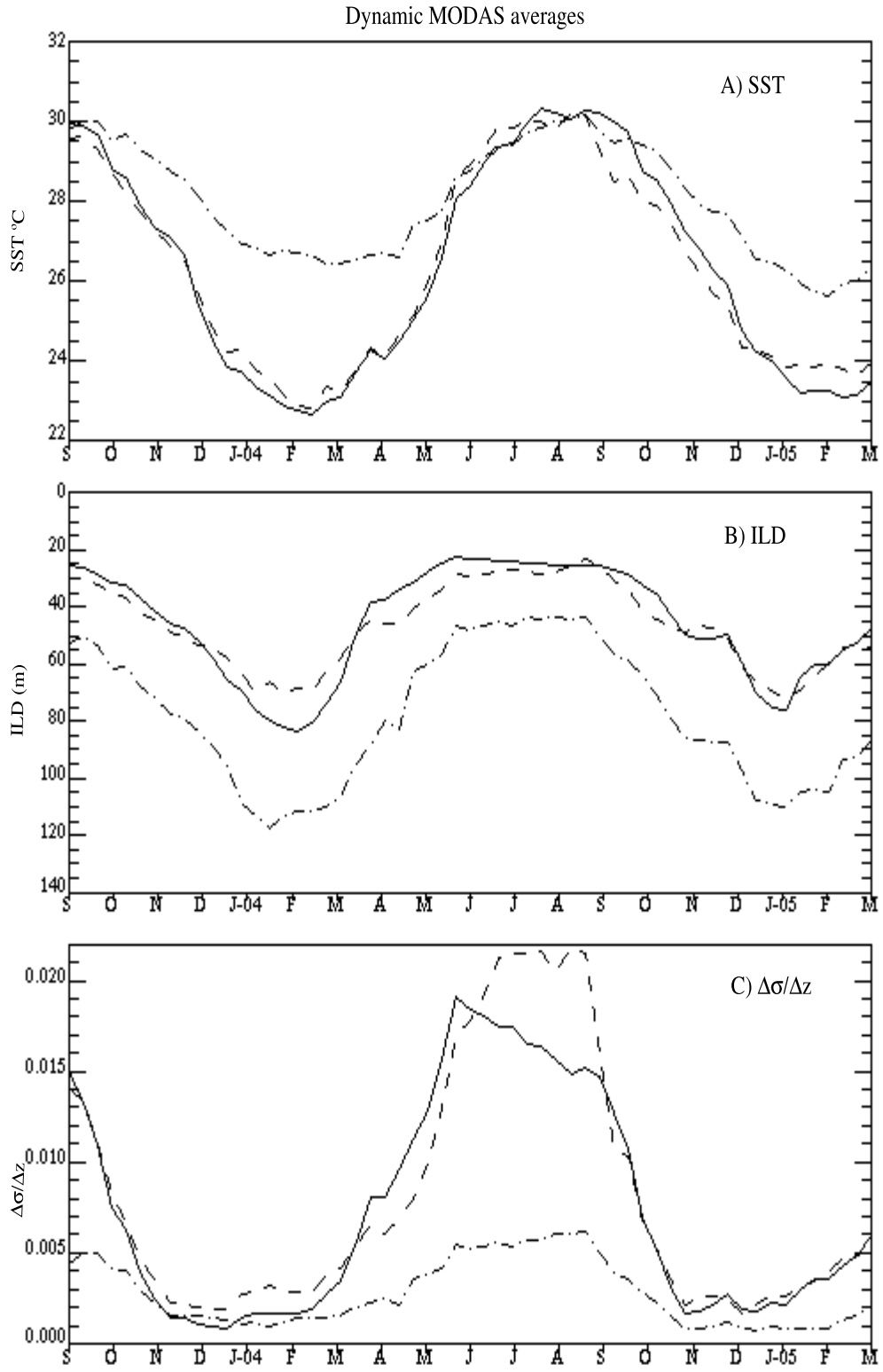

Figure 2. Dynamic MODAS averages for A) Sea Surface Temperature, B) Isothermal Layer Depth (ILD), and C) temperature-based stratification through 30-meters. Solid line is the WGOM, dashed line – EGOM, and dot-dashed line NWC.

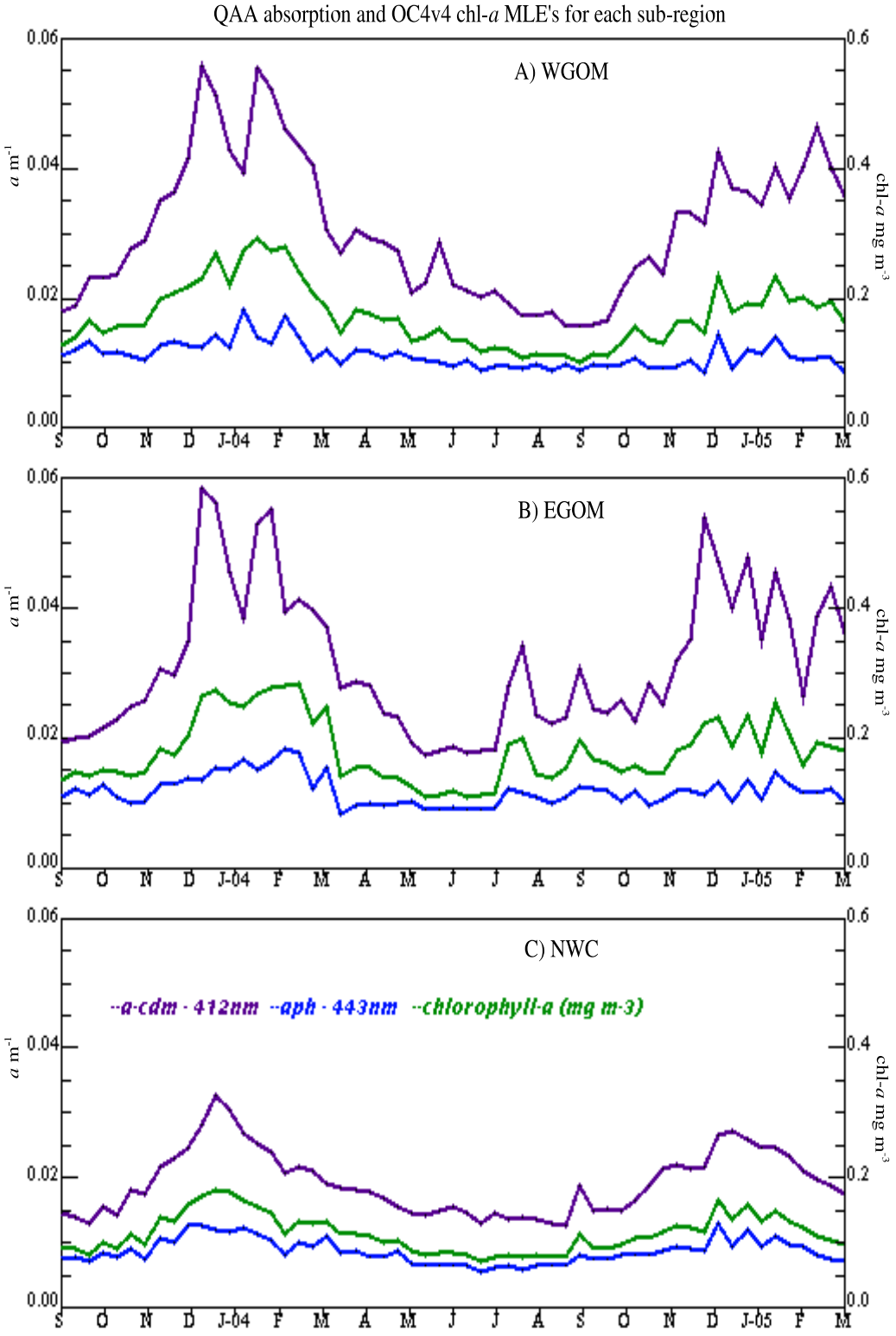

Figure 3. QAA constituent absorption and OC4v4 Csat MLE's for A) WGOM, B) EGOM, and C) NWC.

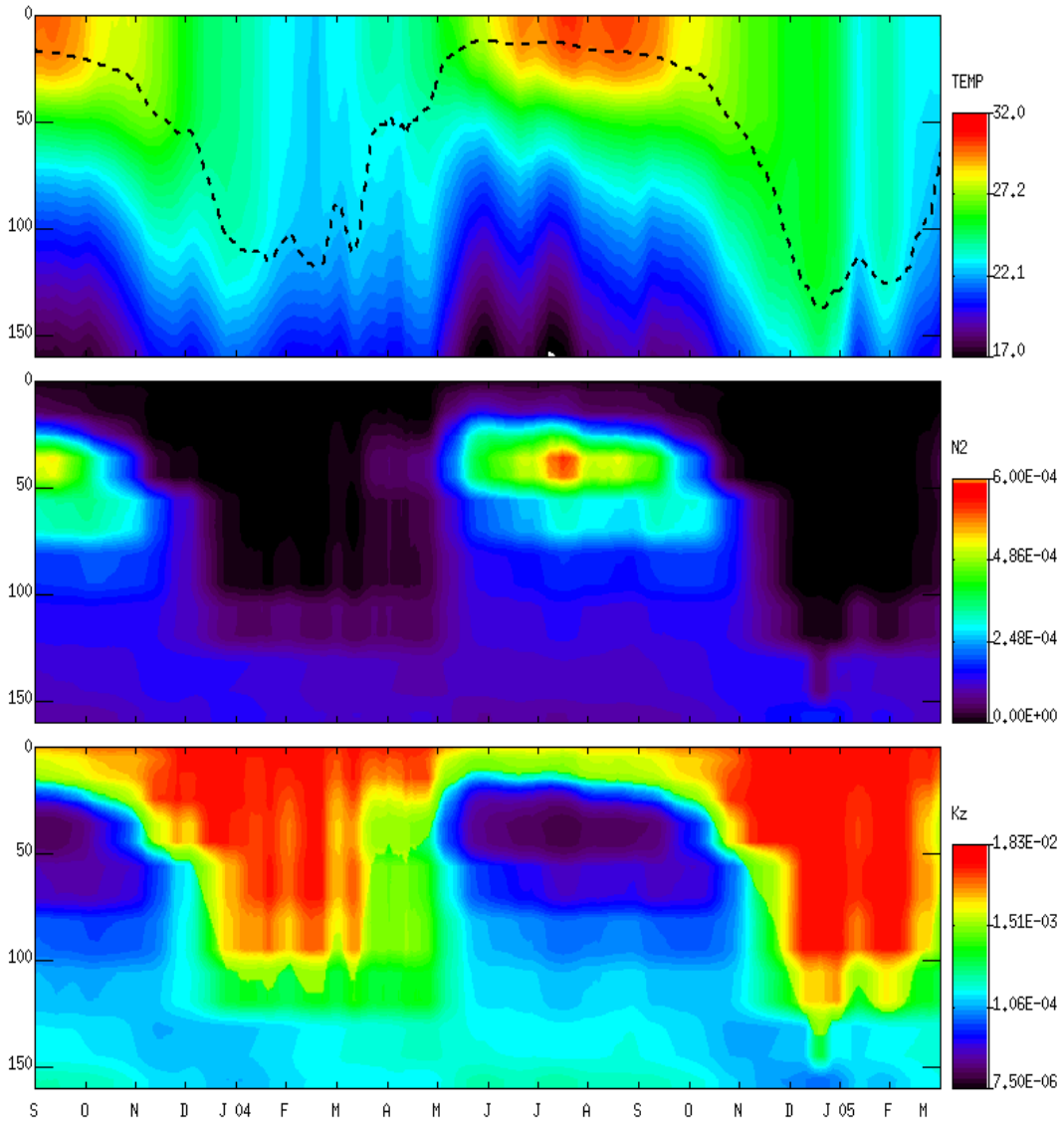

Figure 4. Top – Dynamic MODAS temperature (ºC) in the upper 100-meters for ~93ºW and ~25ºN, western Gulf of Mexico, dashed line is the isothermal layer depth. Middle – MODAS imputed Brunt-Vaisala frequency, N^2. Bottom – Imputed coefficient of vertical eddy diffusion (m^2 s^{-1}) from MODAS temperature/salinity fields.

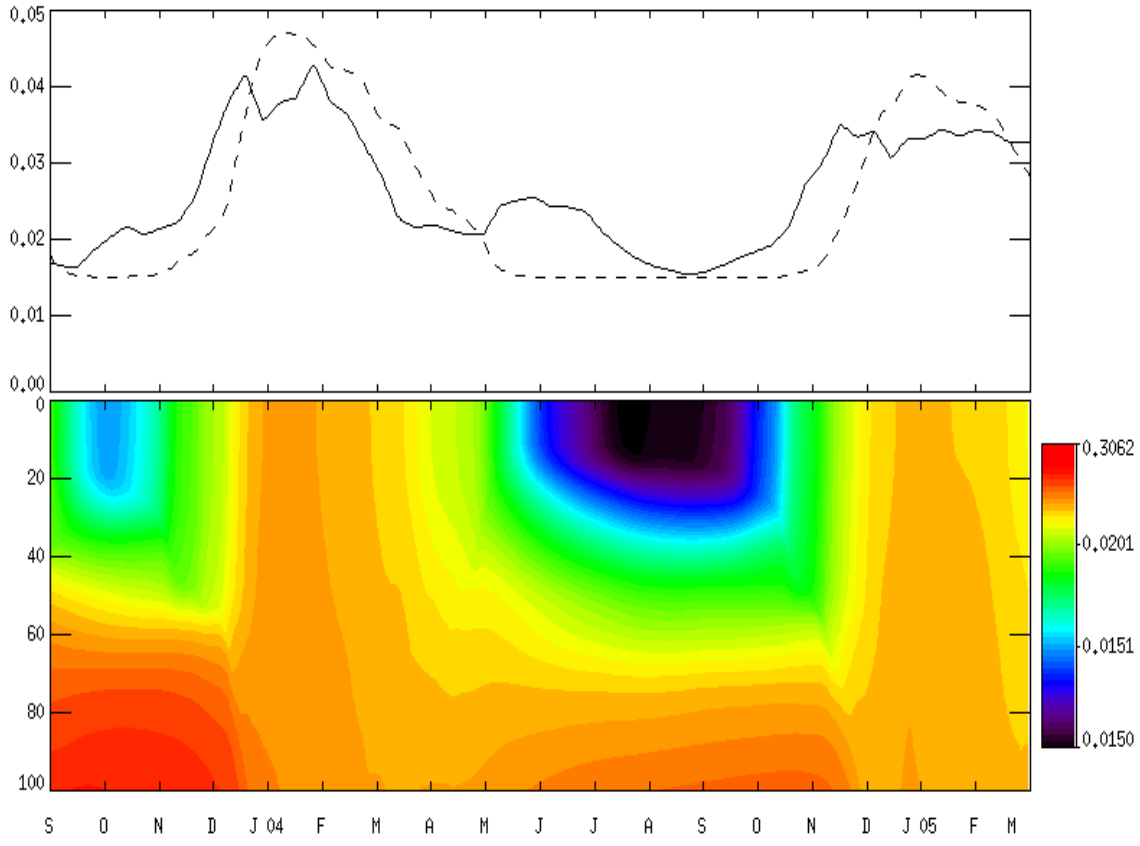

Figure 5. Top: SeaWiFS inferred absorption due to cdm (412nm) in the western Gulf of Mexico – solid line, the simulated surface CDOM absorption –dashed line. Bottom: simulated vertical distribution of CDOM (shown as absorption at 412nm) of the upper 100-meters.